DOCUMENT RESUME

ED 275 523 SE 047 505

TITLE A Guide to Curriculum Development in Science. A Curriculum Coordinating Committee Report.
INSTITUTION Iowa State Dept. of Education, Des Moines. Div. of Instructional Services.
PUB DATE Sep 86
NOTE 76p.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC04 Plus Postage.
DESCRIPTORS Biological Sciences; Cognitive Development; Cognitive Objectives; Curriculum Design; *Curriculum Development; Curriculum Evaluation; Earth Science; Educational Philosophy; *Elementary School Science; Elementary Secondary Education; Instructional Improvement; Physical Sciences; Process Education; *Science Curriculum; Science Education; *Secondary School Science; State Curriculum Guides
IDENTIFIERS *Iowa

ABSTRACT

Designed to facilitate development of local school district curricula, this document provides science educators with guidelines for conducting an assessment of K-14 programs as well as offering "essential" process skills and knowledge items for synthesizing the most appropriate student outcomes in science courses. The booklet is divided into three major sections. The first section presents a rationale, philosophy, and goals for a school's science program. The second section, "Scope/Sequence/Strategies" presents: (1) the Iowa Science Curriculum Model; (2) a science process skills hierarchy; (3) suggested levels of emphasis; and (4) suggestions for curriculum emphasis and development in life science, earth science, and physical science. The third section of the guide urges that an evaluation component be built into the curriculum with an implementation schedule, and addresses two evaluation categories: program quality and student progress. The appendices include the "Code of Iowa" requirements and standards applicable to science education and a list of resources for science teachers. (TW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

A Curriculum Coordinating Committee Report

ED275523

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

A Guide to Curriculum Development in Science

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Dean Crocker

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE 047 505

Iowa Department of Education

SE

A GUIDE TO CURRICULUM DEVELOPMENT IN SCIENCE

Curriculum Coordinating Committee Report
Iowa Department of Education

Others in this series of curriculum guides:
Arts, Foreign Language, Language Arts, Mathematics and Social Studies

State of Iowa
DEPARTMENT OF EDUCATION
Grimes State Office Building
Des Moines, Iowa 50319-0146

STATE BOARD OF EDUCATION

Lucas DeKoster, President, Hull
Dianne L.D. Paca, Vice President, Garner
Betty L. Dexter, Davenport
Thomas M. Glenn, Des Moines
Karen K. Goodenow, Wall Lake
Francis N. Kenkel, Defiance
John Moats, Council Bluffs
Mary E. Robinson, Cedar Rapids
Harlan W. Van Gerpen, Cedar Falls

ADMINISTRATION

Robert D. Benton, Director of the Department of Education
Mavis Kelley, Administrative Assistant
James E. Mitchell, Deputy Director

Instructional Services Division

Carol McDanolds Bradley, Administrator
A. John Martin, Chief, Instruction and Curriculum Bureau
Paul Spurlock, Assistant Chief
Jack A. Gerlovich, Consultant, Science Education

Publications Staff

Lisa Bartusek, Information Specialist
Tonya Cox, Graphic Artist
Carl Rejba, Graphic Artist

September 1986

C O N T E N T S

FOREWORD v

PREFACE. vi

ACKNOWLEDGEMENTS vii

SCIENCE CURRICULUM COORDINATING COMMITTEE. viii

RATIONALE/PHILOSOPHY/GOALS

Rationale 3

Philosophy. 4

Science Program Goals for Students. 5

SCOPE/SEQUENCE/STRATEGIES

Iowa Science Curriculum Model 9

Science Process Skills Hierarchy. 10

Levels of Emphasis. 12

Life Science. 13

Earth Science 27

Physical Science. 45

EVALUATION

Evaluation. 61

Implementation Schedule 67

APPENDICES

Appendix A: Code of Iowa Requirements and Standards. 71

Appendix B: Resources for Science Teachers 74

FOREWORD

Curriculum development is a synergistic, evolutionary, ongoing process which builds on successful practices and techniques. An effective curriculum stimulates each student to achieve his or her personal best and prepares the student to meet a rapidly changing world. An effective curriculum is a challenge to students and educators. It challenges students to continually achieve and educators to continually develop their teaching techniques.

This guide is a result of a 1985 mandate from the Iowa General Assembly, calling for the Department of Education to develop "subject matter committees and committees that cross subject matter lines for coordination of curriculum at all education levels."

This mandate was a response to one of the major recommendations of the Legislature's Excellence in Education Task Force report of 1984, First in the Nation in Education (FINE). The Department of Education based its plan for implementing the legislation on recommendations from the report. The Department established six subject matter committees of 15 to 17 members for the arts, foreign languages, language arts, mathematics, sciences, and social studies. The committees were composed of elementary teachers, secondary teachers, merged area school faculty, college and university faculty members, area education agency consultants, school district curriculum coordinators, and other education professionals.

The committees devoted their first year of activity to the vertical articulation of each subject area. This guide is the result of that work. The FINE report notes the importance of horizontal articulation across subject areas, developing such skills as reading and comprehending, writing, speaking and listening, problem solving, conceptualizing, reasoning, analyzing, and learning to learn. This guide will be used as a basis for horizontal articulation in coming years.

The best curriculum is not mandated or enforced from outside. It results from the active involvement of teachers and administrators striving to meet the needs of students. It combines new processes and research about effective curriculum with the experience and expertise of teachers, administrators, and specialists.

This publication is designed to guide faculties and administrators in developing curriculum and improving instruction in science. It is intended to help districts enhance and build upon their current local curriculum.

Robert D. Benton

Robert D. Benton, Ed.D.
Director, Iowa Department of Education

PREFACE

The Iowa Science Curriculum Coordinating Committee presents A Guide to Curriculum Development in Science to science educators as a "working document." The guide will continue to evolve and improve as science educators work with it in various educational settings.

A Guide to Curriculum Development in Science was designed to facilitate development of the local school district curriculum. It provides science educators with proven guidelines for conducting a curriculum assessment as well as the essential "process skills" and "knowledge items" (life, earth, and physical sciences) for synthesizing the most appropriate "student outcomes" for their courses.

Reactions to the guide are welcome and should be made to Jack A. Gerlovich, science consultant, Iowa Department of Education, Grimes State Office Building, Des Moines, Iowa 50319, (515) 281-3249.

A C K N O W L E D G E M E N T S

The Department of Education would like to commend the Science Curriculum Coordinating Committee for their dedication and expertise in synthesizing A Guide to Curriculum Development in Science. The working guide will help schools develop and refine their local science curriculum and ultimately improve the teaching for all Iowa students.

SCIENCE CURRICULUM COORDINATING COMMITTEE

This publication was developed with the aid and advice of a 15-member committee of science professionals from around the state. As representatives of the readers and users of the model, they helped to ensure that this publication reflects the needs and views of those who will use it.

Jan Anderson
Teacher
Cedar Heights Elementary School
Cedar Falls

Paul Anderson
Teacher
Shenandoah Middle School
Shenandoah

Carolyn Brockway
Teacher
Washington High School
Cedar Rapids

Jack Duffy
Principal
East Elementary School
Sheldon

Marlene Gaston
Teacher
Kalona Elementary School
Mid-Prairie Community Schools
Kalona

Jack A. Gerlovich (Chair)
Science Consultant
Instructional Services Division
Department of Education
Des Moines

Richard Huber
President
Iowa Science Teacher Section
Science Supervisor
Iowa City Community Schools
Iowa City

Harold Hulleman (Vice Chair)
Assistant Superintendent
Linn-Mar Community Schools
Marion

Betty Husted
Teacher
Shellsburg Junior-Senior High School
Shellsburg

Father Leonard Kenkel
Teacher
Dowling High School
West Des Moines

Richard Lampe
Biology Department
Buena Vista College
Storm Lake

Lloyd Phillips (Vice Chair)
Teacher
Knoxville Junior High School
Knoxville

Roy Saigo (Vice Chair)
Dean, College of Natural Sciences
University of Northern Iowa
Cedar Falls

Pat Shier
Math/Science Consultant
Area Education Agency 16
Burlington

Burgess Shriver
Math/Science
Des Moines Area Community College
Ankeny

Rationale
Philosophy
Goals

R A T I O N A L E

During the 1980s, much attention has focused on education in the United States. Many studies reported on the status of "excellence" in education in American schools, and especially on the science and mathematics curricula. Concerns have arisen because of decreases in SAT and ACT scores, as well as from the lower placement of young math students in international examinations. American political and educational leaders fear the United States is falling behind in global prominence and in basic research and technology in comparison to its economic competitors, specifically Japan, Germany, and Russia.

Iowa historically has been a national leader in average SAT and ACT scores. Our leaders, however, are concerned about losing ground and maintaining our educational prominence. Concomitant with this issue, legislators note the large fiscal commitment to education and want more commitment to accomplishments in education. Consequently, the Iowa legislature mandated that six curriculum coordinating committees be created. The science committee was charged with identifying "essential student outcomes" (K-14), suggesting ways to implement curriculum improvements, and devising methods of evaluation in the physical, biological, and earth sciences.

This report is an outline of the knowledge and process skills appropriate for K-14 students. Examples are listed to give teachers a model for designing science instruction. This is not a state-mandated curriculum. It is a guide for teachers and school districts to use when developing curricula for K-14 programs. In order to perpetuate autonomy, the science committee intends that materials, resources, and examples will be selected locally.

PHILOSOPHY OF SCIENCE EDUCATION

Science is a body of knowledge concerning natural phenomena and a disciplined, sequential process for verifying knowledge and resolving problems.

Science education consists of three essential components: knowledge, skills, and application of scientific information in resolving problems. Knowledge refers to the facts, theories, and principles of science. The skills or processes of science include activities embodied in the scientific method, which encompasses the ability to formulate and state hypotheses and to evaluate them by experimentation or observation. Application is the use of science content and processes not only in work but also in personal, social, and political decision making.

Schools must provide science education for all students, regardless of sex, race, or capability. Within schools, a climate should exist that encourages students to observe and question the world around them as well as to seek verification of proposed answers.

Science teachers are responsible for developing students' confidence in their ability to understand how things work according to natural principles.

Science teachers must provide all students with a firm grounding in science content and skills, as well as in the applications and technology of science. To accomplish this, teachers need to combine classroom study with practical experiences in school laboratories and field studies.

Students must develop a basic understanding of science and technology in order to become responsible and effective citizens. As future citizens they will be required to make decisions concerning social, technological, medical, and environmental problems that will impact their community and others throughout the world.

SCIENCE PROGRAM
GOALS FOR STUDENTS

1. To develop the science process skills of observing, measuring, classifying, exploring, recording, predicting, inferring, hypothesizing, investigating, experimenting, reporting, decision making, and valuing.

2. To gain knowledge of major facts and concepts in science.

3. To be able to seek information and to carry out investigations to verify or generate information.

4. To demonstrate the ability to approach problems and to solve them in a systematic way.

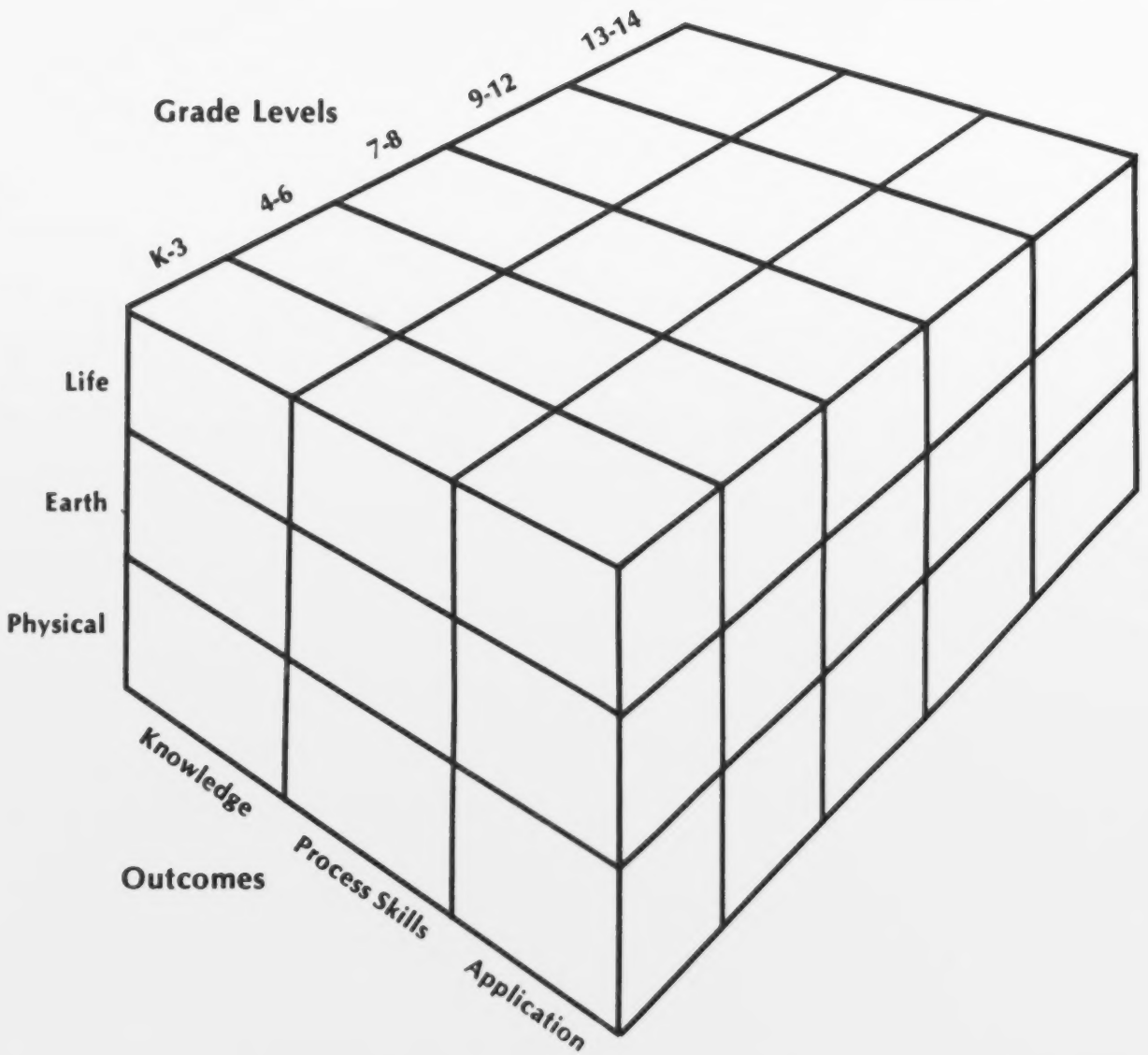
5. To be aware of societal issues caused by the application of science and technology.

6. To make value decisions related to themselves, their society, and their environment.

7. To be aware of the importance of science in many different careers.

Scope Sequence Strategies

Science Curriculum Model



SCIENCE PROCESS SKILLS HIERARCHY

Successful student scientific reasoning exemplifies both knowledge understanding, and use of hands-on process skills. In this guide, the hierarchy of process skills listed below enhances the development of students' reasoning abilities. By following the suggested scope and sequence for introducing these process skills and knowledge items (student outcomes), the teacher's instruction can become increasingly effective and students can better master the whole process of doing science.

To develop a student's observing skills. Observing means using the senses to obtain information or data about objects and events.

To develop a student's measuring skills. Measuring is the process of using numbers and equipment to quantify observations.

To develop a student's classifying skills. Classifying is the process used to impose order on collections of objects and events to show similarities, differences, and interrelationships.

To develop a student's exploring skills. Exploring is the process of looking into new and unknown situations.

To develop a student's recording skills. Recording is the process of logical quantification and manipulation of data.

To develop a student's predicting skills. Predicting is the process of formulating a specific forecast based on observations, measurements, and relationships between variables.

To develop a student's inferring skills. Inferring is the process of using logic to draw conclusions from data.

To develop a student's hypothesizing skills. Hypothesizing is the process of formulating testable scientific generalizations.

To develop a student's investigating skills. Investigating is the process of applying logical reasoning to solve new or unique problems.

To develop a student's experimenting skills. Experimenting is the process of using all the scientific processes in conducting a controlled test of specific scientific hypotheses.

To develop a student's reporting skills. Reporting is writing a paper based upon observations, measurements, and data obtained with investigating or experimenting.

To develop a student's decision-making skills. Decision making is using scientific data to make logical decisions.

To develop a student's valuing skills. Valuing is determining the relevance or ethical nature of scientific information.

LEVELS OF EMPHASIS

NA Not appropriate for this grade level

1 - Incidental: Learning may occur as it arises incidentally in the classroom.

Note: In the levels below, all the skills listed include those in the preceding levels. Also, a low number does not exclude brief reaches to higher levels, possibly to show the relevance of the topic to the student's life.

2 - Awareness: The student becomes familiar with the topic. Skills used include observing, measuring, and classifying.

3 - Comprehension: The student is able to define and understand the topic. Additional skills include exploring, recording, and predicting.

4 - Application: The student uses his or her understanding of the topic for the study of science and personal use. Additional skills include inferring, hypothesizing, and investigating.

5 - Analysis and Evaluation: Given choices, the student can make logical decisions concerning the topic relative to his or her life and society. Additional skills include experimenting, reporting, decision making, and valuing.

LIFE SCIENCE

SUGGESTIONS FOR

CURRICULUM EMPHASES AND DEVELOPMENT

LIFE SCIENCE
SUGGESTED SCOPE/SEQUENCE WITH LEVELS OF EMPHASIS

Knowledge Topics	Grade Level K-3	4-6	7-8	9-12	13-14
Animals					
Groups (taxa)	2	3	4	5	5
Structure (anatomy)	1	2	3	4	4
Function (physiology)	1	2	3	4	5
Behavior (response)	1	2	3	3	4
Plants					
Groups (taxa)	2	3	4	5	5
Structure (anatomy)	1	2	3	4	4
Function (physiology)	1	1	2	3	4
Behavior (response)	1	1	2	3	4
Microbes					
Groups (taxa)	1	1	2	2	2
Structure (anatomy)	NA	NA	3	3	3
Function (physiology)	NA	NA	2	2	2
Response to stimuli	NA	NA	2	2	2
Evolution					
Genetics	1	1	2	3	4
Natural selection	NA	1	2	4	5
Ecology					
Life cycles	1	2	3	3	4
Populations	1	2	3	4	5
Community/Ecosystem	1	2	3	4	5
Interaction among organisms	1	3	3	4	5
Conservation	2	3	4	5	5
Human systems					
Skeletal	1	2	4	4	5
Muscular	1	2	4	4	5
Nervous	1	2	4	4	4
Digestive	1	3	4	4	5
Circulatory	1	3	4	4	5
Reproductive	2	3	4	4	5
Endocrine	NA	2	4	4	5
Excretory	1	2	4	4	5
Integumentary	2	3	4	4	5
Respiratory	2	3	4	4	5
Health/Hygiene	2	3	4	5	5
Disease	2	2	4	5	5
Societal interaction	1	2	4	4	5
Biotechnology/Ethics	1	2	4	4	5
Safety	3	4	4	4	5

Scale to interpret the suggested level of emphasis of each science topic in the curriculum: (See Levels of Emphasis, page 12)

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

LIFE SCIENCE
SUGGESTED STUDENT OUTCOMES DEVELOPMENT TABLE

K-3

Students will use the process skills to become AWARE of the following topics

Process Skills	Knowledge Topics
Observing	Animals Groups Plants Groups Ecology Conservation Human systems Reproductive Excretory Integumentary Respiratory Health/Hygiene Disease Safety
Measuring	
Classifying	

4-6

Students will use the process skills to EXPLORE and KNOW the following topics

Process Skills	Knowledge Topics
Observing	Animals Groups Structure Function Behavior Plants Groups Structure Evolution Genetics Ecology Life cycles Populations Community/Ecosystem Interaction among organisms Conservation Human systems Skeletal Muscular Nervous Digestive Circulatory Reproductive Endocrine Excretory Integumentary Respiratory Health/Hygiene Disease Societal interaction Biotechnology/Ethics Safety
Measuring	
Exploring	
Recording	
Predicting	

Life Science Student Outcomes, cont.

7-8 Students will use the process skills to KNOW and INVESTIGATE the following topics		9-12 Students will use the process skills to COMPREHEND, APPLY, and ANALYZE the following topics	
Process Skills	Knowledge Topics	Process Skills	Knowledge Topics
	Animals		Animals
	Groups (taxa)		Groups (taxa)
	Structure (anatomy)		Structure (anatomy)
	Function (physiology)		Function (physiology)
Observing	Behavior (response)	Observing	Behavior (response)
	Plants		Plants
Measuring	Groups (taxa)	Measuring	Groups (taxa)
	Structure (anatomy)		Structure (anatomy)
Classifying	Function (physiology)	Classifying	Function (physiology)
	Behavior (response)		Behavior (response)
Exploring	Microbes	Exploring	Microbes
	Groups (taxa)		Groups (taxa)
Recording	Structure (anatomy)	Recording	Structure (anatomy)
	Function (physiology)		Function (physiology)
Predicting	Response to stimuli	Predicting	Response to stimuli
	Evolution		Evolution
Inferring	Genetics	Inferring	Genetics
	Natural selection		Natural selection
Hypothesizing	Ecology	Hypothesizing	Ecology
	Life cycles		Life cycles
Investigating	Populations	Investigating	Populations
	Community/Ecosystems		Community/Ecosystems
	Interaction among organisms	Experimenting	Interaction among organisms
	Conservation	Reporting	Conservation
	Human systems		Human systems
	Skeletal		Skeletal
	Muscular		Muscular
	Nervous		Nervous
	Digestive		Digestive
	Circulatory		Circulatory
	Reproductive		Reproductive
	Endocrine		Endocrine
	Excretory		Excretory
	Integumentary		Integumentary
	Respiratory		Respiratory
	Health/Hygiene		Health/Hygiene
	Disease		Disease
	Societal interaction		Societal interaction
	Biotechnology/Ethics		Biotechnology/Ethics
	Safety		Safety

13-14
Students will use the process skills
To SYNTHESIZE and EVALUATE the following topics

Process Skills	Knowledge Topics
Observing	Animals Groups (taxa)
Measuring	Structure (anatomy) Function (physiology)
Classifying	Behavior (response) Plants
Exploring	Groups (taxa) Structure (anatomy)
Recording	Function (physiology) Behavior (response)
Predicting	Microbes Groups (taxa)
Inferring	Structure (anatomy) Function (physiology)
Hypothesizing	Response to stimuli Evolution
Investigating	Genetics Natural selection
Experimenting	Ecology Life cycles
Reporting	Populations Community/Ecosystems
Decision making	Interaction among organisms Conservation
Valuing	Human systems Skeletal
	Muscular Nervous
	Digestive Circulatory
	Reproductive Endocrine
	Excretory Integumentary
	Respiratory Health/Hygiene
	Disease Societal interaction
	Biotechnology/Ethics Safety

DISTRICT SCOPE/SEQUENCE FOR LIFE SCIENCE

Knowledge Topics	Grade Level K	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Animals															
Groups (taxa)															
Structure (anatomy)															
Function (physiology)															
Behavior (response)															
Plants															
Groups (taxa)															
Structure (anatomy)															
Function (physiology)															
Behavior (response)															
Microbes															
Groups (taxa)															
Structure (anatomy)															
Function (physiology)															
Response to stimuli															
Evolution															
Genetics															
Natural selection															
Ecology															
Life cycles															
Populations															
Community/Ecosystem															
Interaction among organisms															
Conservation															
Human systems															
Skeletal															
Muscular															
Nervous															
Digestive															
Circulatory															
Reproductive															
Endocrine															
Integumentary															
Respiratory															
Health/Hygiene															
Disease															
Societal interaction															
Biotechnology/Ethics															
Safety															

Scale to interpret levels of emphasis for each topic:
(See Suggested Scope/Sequence, page 15, and Levels of Emphasis, page 12):

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

LIFE SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(K-3 Sample)

Knowledge topic: Plants Grade level: K-3

STUDENT OUTCOME EXPECTED

Student will be able to:

see that sunlight is needed for green plants to grow and survive.

EMPHASIS LEVEL (circle one)

(Awareness (2)) Comprehension (3) Application (4)

Analysis and Evaluation (5)

RESOURCES

McGraw-Hill Science. Webster Division, McGraw-Hill Book Co., 1983.

ACTIVITIES

Plant wheat seeds in two cups of soil. Keep both cups in a dark area until the seeds are sprouted. Both plants will have white leaves. Move one cup of plants to a sunlit area. The leaves will turn green. The leaves of the plants in the dark area will stop growing, die, and drop off.

EVALUATION

a. Develop a written test
b. Discuss the experiment and what happened to the plants.
c. Write a summary of the experiment.
d. Teacher observes each student's class participation.

LIFE SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(4-6 Sample)

Knowledge topic: Invertebrates Grade level: 4-6

STUDENT OUTCOME EXPECTED

Student will be able to:

1) group through observation a variety of invertebrate animals and
2) demonstrate through explorations with these invertebrates how they fit into a food web.

EMPHASIS LEVEL (circle one)

Awareness (2) (Comprehension (3)) Application (4)

Analysis and Evaluation (5)

RESOURCES

Science and Children articles
Pond Life Series books and articles
Books and articles on invertebrates
Catalogs of biological science supply houses
Arthur A. Carin, Teaching Science Through Discovery, Charles E. Merrill Publishing Co., 1985 (see Appendix B)
Filmstrips on invertebrates
Films on invertebrates or pond life
Computer program simulations about invertebrate animals or pond life creatures
A local biologist, naturalist, or zoologist
Field trip to a pond, stream, or zoology laboratory

ACTIVITIES

The teacher will provide some stock cultures of invertebrates from a regional biological supply house for student use and study. Suggested creatures are protozoa (Blepharisma, Spirostomum, or stentor), hydra, planaria, vinegar eel, cylops or daphnia, and tardigrades. Students should make fresh slide mounts of cultures using a dropper, a slide, and a plastic cover slip. Students can observe these invertebrates with a pocket miniscope or a strong magnifier. Students should make drawings of the organisms they observe. The student can use a concave-depression slide to observe the interaction of any two invertebrates. In this way the student will find out what eats what and, afterward, should graphically develop or make a model of a food web.

EVALUATION

a. Students should be able to design a food web of the sketches made, after observing the stock cultures.

b. Students should be able to make a model of the organisms and show their relationships to each other in a food web.

LIFE SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(7-8 Sample)

Knowledge topic: Health/Hygiene Grade level: 7-8

STUDENT OUTCOME EXPECTED

Student will be able to:

predict what happens when a person breathes in nicotine.

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) (Application (4))

Analysis and Evaluation (5)

RESOURCES

Textbooks, library references
American Cancer Society materials
transparencies
lung model
films, charts
Guest: emergency medical technician

ACTIVITIES

1. Laboratory experience counting gill cover movements in goldfish influenced by nicotine.
2. Library research on smoking and lung disease.

EVALUATION

Students will list changes in the lung's response to inhaled cigarette smoke.

LIFE SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(9-12 Sample)

Knowledge topic: Plant variety Grade level: 9-12

STUDENT OUTCOME EXPECTED

Student will be able to:

graph the variety within a tree species.

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) (Application (4))

Analysis and Evaluation (5)

RESOURCES

Printed: textbooks, journals

Natural: leaves from one species of tree

Other: ruler, graph paper

ACTIVITIES

Collect leaves (100) from one species of tree. Measure the length (or width) of leaves, and record on a data table. Make a graph using the frequency of leaves on the vertical axis and the length (or width) on the horizontal axis. The graph will show the variety in one species.

EVALUATION

a. Student will produce a graph on the variety of leaves in one species.
b. Student will be able to predict the variety of another characteristic in one species.
c. Student will be able to read a similar graph for a similar trait in another species.

LIFE SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(13-14 Sample)

Knowledge topic: Populations Grade level: 13-14

STUDENT OUTCOME EXPECTED

Student will be able to:

evaluate the factors affecting population regulation of a species, e.g. Homo sapiens.

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) Application (4)

(Analysis and Evaluation (5))

RESOURCES

Textbook information
Videotape: Nova, Nature
Some news magazines: Three articles in the Jan./Feb. issue of Science 86 under the cover title, "State of the Species: The Myths of Overpopulation":
Tierney, John. (1986). "Fanisi's Choice." Science 86, 7 (1), 26-42.
Easterbrook, Greg. (1986). "A Feeding Machine." Science 86, 7 (1), 48-54.
Ackerman, Laura, et al. (1986). "The Successful Animal." Science 86, 7 (1), 55-59.

ACTIVITIES

Lecture.

Discussion of videotape and a comparison of the news magazine article with textbook information.

Guest lecture (indicate job title or expertise suggested).

EVALUATION

a. Test
b. In-class essay following the discussion
c. Article-review writing assignment
d. Questions for guest lecturer written before lecturer's appearance

LIFE SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(Teacher's Sample)

Knowledge topic: _____ Grade level: _____

STUDENT OUTCOME EXPECTED

Student will be able to:

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) Application (4)

Analysis and Evaluation (5)

RESOURCES

ACTIVITIES

EVALUATION

EARTH SCIENCE

SUGGESTIONS FOR

CURRICULUM EMPHASES AND DEVELOPMENT

EARTH SCIENCE
SUGGESTED SCOPE/SEQUENCE WITH LEVELS OF EMPHASIS

Knowledge Topics	Grade Level K-3	4-6	7-8	9-12	13-14
Geology					
Earth materials					
Earth's interior, mantle, crust	1	3	3	5	5
Minerals	1	3	3	4	5
Rocks	2	3	3	4	5
Soils	1	3	3	4	5
Earth processes					
Weathering/Erosion/ Deposition	2	3	3	4	5
Mountain building	NA	2	3	3	4
Plate tectonics	NA	1	3	3	4
Glaciers	1	3	3	5	5
Movement:					
Water, wind, waves	1	3	3	4	5
Lakes, rivers	1	3	3	5	5
Earth history					
Geologic time	NA	1	2	3	4
Fossils and life on Earth	1	3	3	3	4
Evolution of Earth	NA	2	2	4	4
Meteorology					
Atmosphere					
Composition	1	3	3	4	5
Motion-water cycle	2	3	3	4	5
Weather					
Air masses, fronts	NA	2	2	3	4
Pressure systems, disturbances	NA	2	2	3	4
Precipitation, clouds	1	2	2	3	4
Mapping, forecasting	2	3	3	5	5
Climate					
Elevation	1	3	3	4	5
Latitude	1	3	3	4	5
Physical barriers	1	3	3	4	5
Location	1	3	3	4	5
Impact on economy	1	3	3	5	5

Scale to interpret suggested levels of emphasis for each science topic in the curriculum:

(See Levels of Emphasis, page 12):

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

Earth Science Scope/Sequence, cont.

Knowledge Topics	Grade Level K-3	4-6	7-8	9-12	13-14
Astronomy					
Solar system					
Sun	2	4	4	5	5
Moon	2	3	3	4	5
Planets and other bodies	2	3	3	3	4
Movement (seasons, time, eclipses)	1	3	3	4	5
Space exploration	1	3	4	5	5
Stars, galaxies, universe					
Evolution	1	2	3	4	5
Composition	1	2	3	4	5
Stellar bodies	1	2	3	3	4
Constellations	1	2	3	3	NA
Water					
Oceans					
Composition	1	2	3	3	4
Motion	1	2	3	4	5
Floor	1	2	3	4	4
Uses	1	2	3	3	5
Rivers, lakes					
Composition	1	2	2	4	4
Sedimentation	1	2	2	3	5
Motion	1	2	3	3	5
Bed	1	2	2	3	4
Uses	1	2	2	3	5
Environmental issues*					
Soil	1	3	4	5	5
Air	2	3	4	5	5
Water	2	3	4	5	5
Safety	4	4	4	5	5

*These issues may be included in the respective units or treated as a separate unit.

Scale to interpret suggested levels of emphasis for each science topic in the curriculum:
(See Levels of Emphasis, page 12):

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

EARTH SCIENCE
SUGGESTED STUDENT OUTCOMES DEVELOPMENT TABLE

K-3

Students will use the process skills to become AWARE of the following topics

Process Skills	Knowledge Topics
Observing	Geology
Measuring	Earth materials
Classifying	Rocks
Predicting	Earth processes
	Weathering/Erosion/ Deposition
	Meteorology
	Atmosphere
	Motion-water cycle
	Weather
	clouds
	Mapping, forecasting
	Astronomy - solar system
	Sun
	Moon
	Planets and other bodies
	Environmental issues*
	Air
	Water
	Safety

4-6

Students will use the process skills to EXPLORE and KNOW the following topics

Process Skills	Knowledge Topics
	Geology
Observing	Earth materials
	Earth's interior
Measuring	Minerals
	Rocks
Classifying	Soils
	Earth processes
Exploring	Weathering/Erosion/ Deposition
Recording	Mountain building
	Glaciers
Predicting	Movement:
	Water, wind, waves lakes, rivers
	Earth history
	Fossils
	Evolution of Earth
	Meteorology
	Atmosphere
	Composition
	Motion-water cycle
	Weather
	Air masses, fronts
	Pressure systems, disturbances
	Precipitation, clouds
	Mapping, forecasting
	Climate
	Elevation
	Latitude
	Physical barriers
	Location
	Impact on economy

*These issues may be included in the respective units or treated as a separate unit.

Earth Science Student Outcomes, cont.

K-3 Students will use the process skills to become AWARE of the following topics	
Process Skills	Knowledge Topics
(See previous page for list of process skills)	

4-6 Students will use the process skills to EXPLORE and KNOW the following topics	
Process Skills	Knowledge Topics
(See previous page for list of process skills)	Astronomy Solar system Sun Moon Planets and other bodies Movement (seasons, (time, eclipses) Space exploration Stars, galaxies, universe Evolution Composition Stellar bodies Constellations Water Oceans Composition Motion Floor Uses Rivers, lakes Composition Sedimentation Motion Bed Uses Environmental issues* Soil Air Water Safety

*These issues may be included in the respective units or treated as a separate unit.

Earth Science Student Outcomes, cont.

7-8 Students will use the process skills to INVESTIGATE the following topics		9-12 Students will use the process skills to COMPREHEND, APPLY, and ANALYZE the following topics	
Process Skills	Knowledge Topics	Process Skills	Knowledge Topics
	Geology		Geology
Observing	Earth materials	Observing	Earth materials
	Earth's interior		Earth's interior
Measuring	Minerals	Measuring	Minerals
	Rocks		Rocks
Classifying	Soils	Classifying	Soils
	Earth processes		Earth processes
Exploring	Weathering/Erosion/ Deposition	Exploring	Weathering/Erosion/ Deposition
Recording	Mountain building	Recording	Mountain building
	Plate tectonics		Plate tectonics
Predicting	Glaciers	Predicting	Glaciers
	Water, wind, waves		Water, wind, waves
Inferring	Lakes, rivers	Inferring	Lakes, rivers
	Earth history		Earth history
Hypothesizing	Geologic time	Hypothesizing	Geologic time
	Fossils		Fossils
Investigating	Evolution of Earth	Investigating	Evolution of Earth
	Meteorology		Meteorology
	Atmosphere	Experimenting	Atmosphere
	Composition		Composition
	Motion-water cycle	Reporting	Motion-water cycle
	Weather		Weather
	Air masses, fronts		Air masses, fronts
	Pressure systems, disturbances		Pressure systems, disturbances
	Precipitation, clouds		Precipitation, clouds
	Mapping, forecasting		Mapping, forecasting
	Climate		Climate
	Elevation		Elevation
	Latitude		Latitude
	Physical barriers		Physical barriers
	Location		Location
	Impact on economy		Impact on economy

7-8		9-12	
Students will use the process skill to KNOW and INVESTIGATE the following topics		Students will use the process skills to to COMPREHEND, APPLY, and ANALYZE the following topics	
Process Skills	Knowledge Topics	Process Skills	Knowledge Topics
(See previous page for list of process skills)	Astronomy Solar system Sun Moon Planets and other bodies Movement (seasons, time, eclipses) Space exploration Stars, galaxies Evolution Composition Stellar bodies Constellations Water Oceans Composition Motion Floor Uses Rivers, lakes Composition Sedimentation Motion Bed Uses Environmental issues* Soil Air Water Safety	(See previous page for list of process skills)	Astronomy - solar system Solar system Sun Moon Planets and other bodies Movement (seasons, (time, eclipses) Space exploration Stars, galaxies Evolution Composition Stellar bodies Constellations Water Oceans Composition Motion Floor Uses Rivers, lakes Composition Sedimentation Motion Bed Uses Environmental issues* Soil Air Water Safety

*These issues may be included in the respective units or treated as a separate unit.

13-14
Students will use the process skills
To SYNTHESIZE and EVALUATE the following topics

Process Skills	Knowledge Topics
Observing	Geology
	Earth materials
Measuring	Earth's interior, mantle, crust
	Minerals
Classifying	Rocks
	Soils
Exploring	Earth processes
	Weathering/Erosion/
Recording	Deposition
	Mountain building
Predicting	Plate tectonics
	Glaciers
Inferring	Movement:
	Water, wind, waves
Hypothesizing	Lakes, rivers
	Earth history
Investigating	Geologic time
	Fossils and life on Earth
Experimenting	Evolution of Earth
	Meteorology
Reporting	Atmosphere
	Composition
	Motion-water cycle
	Weather
	Air masses, fronts
	Pressure systems,
	disturbances
	Precipitation,
	clouds
	Mapping, forecasting
	Climate
	Elevation
	Latitude
	Physical barriers
	Location
	Impact on economy

13-14
Students will use the process skills to
SYNTHESIZE and EVALUATE the following topics

Process Skills	Knowledge Topics
(See previous page for list of process skills)	Astronomy Solar system Sun Moon Planets and other bodies Movement (seasons, time, eclipses) Space exploration Stars, galaxies, universe Evolution Composition Stellar bodies Constellations Water Oceans Composition Motion Floor Uses Rivers, lakes Composition Sedimentation Motion Bed Uses Environmental issues* Soil Air Water Safety

*These issues may be included in the respective units or treated as a separate unit.

DISTRICT SCOPE/SEQUENCE FOR EARTH SCIENCE

Knowledge Topics	Grade Level K	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Geology															
Earth materials															
Earth's interior, mantle, crust															
Minerals															
Rocks															
Soils															
Earth processes															
Weathering/Erosion/ Deposition															
Mountain building															
Plate tectonics															
Glaciers															
Movement: Water, wind, waves															
Lakes, rivers															
Earth history															
Geologic time															
Fossils & life on Earth															
Evolution of Earth															
Meteorology															
Atmosphere															
Composition															
Motion-water cycle															
Weather															
Air masses, fronts															
Pressure systems, disturbances															
Precipitation, clouds															
Mapping, forecasting															
Climate															
Elevation															
Latitude															
Physical barriers															
Location															
Impact on economy															

Scale to interpret levels of emphasis for each topic:
(See Suggested Scope/Sequence, pages 29-30, and Levels of Emphasis, page 12):

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

District Scope/Sequence for Earth Science, cont.

Knowledge Topics	Grade Level K	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Astronomy															
Solar system															
Sun															
Moon															
Planets and other bodies															
Movement (seasons, time, eclipses)															
Space exploration															
Stars, galaxies, universe															
Evolution															
Composition															
Stellar bodies															
Constellations															
Water															
Oceans															
Composition															
Motion															
Floor															
Uses															
Rivers, lakes															
Composition															
Sedimentation															
Motion															
Bed															
Uses															
Environmental issues*															
Soil															
Air															
Water															
Safety															

*These issues may be included in the respective units or treated as a separate unit.

Scale to interpret levels of emphasis for each topic:
(See Suggested Scope/Sequence, pages 29-30, and Levels of Emphasis, page 12):

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

---

EARTH SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(K-3 Sample)

Knowledge topic: Weather Grade level: K-3

STUDENT OUTCOME EXPECTED

Student will be able to:

observe and classify the different kinds of weather in the community.

EMPHASIS LEVEL (circle one)

(Awareness (2)) Comprehension (3) Application (4)

Analysis and Evaluation (5)

RESOURCES

Printed: daily newspaper
Audiovisual:
Pictures of different kinds of weather
Picture symbols of different kinds of weather (sunny, partly sunny, windy, cloudy, rainy, snowy)
Videotape of weather news
Calendar grid (wall-sized)

ACTIVITIES

1. Discuss with students the different kinds of weather. Use large cloud pictures to demonstrate the different kinds of cloud formations.
2. Have students color and/or cut out picture symbols of different kinds of weather.
3. During the opening activities each day, ask students to identify the kind of weather that exists. The teacher may wish to compare their observations with the forecast in the daily newspaper.
4. Have a student place the appropriate symbol on the wall calendar.
5. At the end of the month, have the students count the number of days that were sunny, rainy, etc.

EVALUATION

a. Observe the students' abilities to correctly identify the daily weather type.
b. Observe the students' abilities to maintain a daily weather calendar for a month.

EARTH SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(4-6 Sample)

Knowledge topic: Astronomy Grade level: 4-6

STUDENT OUTCOME EXPECTED

Student will be able to:

predict and then construct a model of the relative distances of the planets from the sun.

EMPHASIS LEVEL (circle one)

Awareness (2) (Comprehension (3)) Application (4)

Analysis and Evaluation (5)

RESOURCES

Encyclopedia, textbooks

Other: There should be 10 stakes per group. Nine stakes are marked with the names of the planets and the tenth is labeled sun. (The stakes could have flags with scale drawings of the planets and the sun.)

Suggested group size: 6-8 students

ACTIVITIES

1. The students will make predictions of how far they think each planet would be from the sun, if the Earth were 150 centimeters from the sun. They will record the predictions.
2. Using reference sources, the students will find the actual distance of the planets from the sun and record these in millions of kilometers.
3. The student will use a scale of one centimeter to equal 1 million km.
4. On the playground, the students will construct a model of the solar system. They will use the scale they developed to measure and place "planet" stakes at recorded distances from the "sun" stake.
5. Students will observe the model they have constructed and compare the relative distances of the planets from the sun.
6. Students will compare the measured distances with their earlier predictions.

EVALUATION

a. The students will be observed while participating in the activity.
b. The students will make a record of their observations, including their predictions, the actual distances, and the scaled distances.
c. The students will write a summary of their observations.
d. The students will describe why it is difficult to travel to other planets.

EARTH SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(7-8 Sample)

Knowledge topic: Geology - Minerals Grade level: 7-8

STUDENT OUTCOME EXPECTED

Student will be able to:

identify a number of minerals provided.

EMPHASIS LEVEL (circle one)

Awareness (2) (Comprehension (3)) Application (4)

Analysis and Evaluation(5)

RESOURCES

Textbook

Films about minerals

Other: mineral samples, streak plates, .1 M HCl in a dropper bottle, pin, penny, a glass, magnifying glass

ACTIVITIES

As a laboratory activity, the students will observe and perform physical and chemical tests (hardness, acidity, luster, color, streak) on a variety of minerals. Students will then record the properties observed in each mineral.

EVALUATION

Students will identify 25 mineral specimens.

EARTH SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(9-12 Sample)

Knowledge topic: Fossils Grade level: 9-12

STUDENT OUTCOME EXPECTED

Student will be able to:

classify fossils into phylum and class.

EMPHASIS LEVEL (circle one)

(Awareness (2)) Comprehension (3) Application (4)

Analysis and Evaluation (5)

RESOURCES

Fossil book, textbook

Film strip, cassette, transparencies

Real fossils

ACTIVITIES

Given a set of fossils, the students will group them according to phylum and class, using resource materials.

The student will list the names and the identifying features of each phylum and class.

EVALUATION

a. Given a number of different real fossils, the students can classify them into phylum and class and give the identifying features of each phylum and class.

or

b. A written test covering the characteristics of phyla.

EARTH SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(13-14 Sample)

Knowledge topic: Water quality Grade level: 13-14

STUDENT OUTCOME EXPECTED

Student will be able to:

infer the effect of karst geology on Iowa groundwater quality.

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) Application (4)

(Analysis and Evaluation (5))

RESOURCES

Textbooks, current newspaper clippings

Videotapes

ACTIVITIES

1. Field trips
2. Laboratory analysis

EVALUATION

Tests
Quizzes
Reports
Group Activities

EARTH SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(Teacher's Sample)

Knowledge topic: _____ Grade level: _____

STUDENT OUTCOME EXPECTED

Student will be able to:

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) Application (4)

Analysis and Evaluation (5)

RESOURCES

ACTIVITIES

EVALUATION

PHYSICAL SCIENCE

SUGGESTIONS FOR

CURRICULUM EMPHASES AND DEVELOPMENT

PHYSICAL SCIENCE
SUGGESTED SCOPE/SEQUENCE WITH LEVELS OF EMPHASIS

Knowledge Topics	Grade Level				
	K-3	4-6	7-8	9-12	13-14
Measurement	1	2	5	5	5
Physics					
Energy	2	3	4	5	5
Force and motion	2	3	4	5	5
Work	2	3	3	5	5
Heat	2	3	3	5	5
Thermodynamics	NA	NA	2	5	5
Fluids	1	1	3	5	5
Wave properties	NA	1	4	5	5
Sound	2	3	4	5	5
Light	2	3	4	5	5
Optics	1	3	3	5	5
Electricity	2	3	3	5	5
Magnetism	2	3	4	5	5
Chemistry					
Properties of matter	2	3	4	5	5
Atomic structure	NA	1	3	5	5
Compounds and mixtures	1	3	3	5	5
Bonding	NA	NA	2	5	5
Formulas of compounds	NA	1	3	5	5
Periodic table	NA	1	3	5	5
Reactions and equations	NA	NA	2	5	5
Properties of gases	NA	NA	3	5	5
Solutions	2	3	3	5	5
Acids, bases, salts	1	2	3	5	5
Equilibrium and kinetics	NA	NA	1	4	5
Nuclear science	NA	NA	1	5	5
Organic chemistry	NA	NA	1	3	3
Biochemistry	NA	NA	1	3	3
Safety	4	4	5	5	5

Scale to interpret the suggested level of emphasis of each science topic in the curriculum:

(See Levels of Emphasis page 12)

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

PHYSICAL SCIENCE
SUGGESTED STUDENT OUTCOMES DEVELOPMENT TABLE

K-3
Students will use the process skills to become AWARE of the following topics

Process Skills	Knowledge Topics
Observing	Physics
	Energy
Measuring	Force and motion
	Work
Classifying	Heat
	Sound
	Light
	Electricity
	Magnetism
	Chemistry
	Properties of matter
	Solutions
	Safety

4-6
Students will use the process skills to EXPLORE and KNOW the following topics

Process Skills	Knowledge Topics
Observing	Measurement
	Physics
Measuring	Energy
	Force and motion
Classifying	Work
	Heat
Exploring	Sound
	Light
Recording	Optics
	Electricity
Predicting	Magnetism
	Chemistry
	Properties of matter
	Compounds and mixtures
	Solutions
	Acids, bases, salts
	Safety

Physical Science Student Outcomes, cont.

7-8 Students will use the process skills to KNOW and INVESTIGATE the following topics		9-12 Students will use the process skills to to COMPREHEND, APPLY, and ANALYZE the following topics	
Process Skills	Knowledge Topics	Process Skills	Knowledge Topics
Observing	Measurement	Observing	Measurement
Measuring	Physics	Measuring	
	Energy		Physics
Classifying	Force and motion	Classifying	Energy
	Work		Force and motion
Exploring	Heat	Exploring	Work
	Thermodynamics		Heat
Recording	Fluids	Recording	Thermodynamics
	Wave properties		Fluids
Predicting	Sound	Predicting	Wave properties
	Light		Sound
Inferring	Optics	Inferring	Light
	Electricity		Optics
Hypothesizing	Magnetism	Hypothesizing	Electricity
	Chemistry		Magnetism
Investigating	Properties of matter	Investigating	Chemistry
	Atomic structure		Properties of matter
	Compounds and mixtures	Experimenting	Atomic structure
	Bonding		Compounds and mixtures
	Formulas of compounds	Reporting	Bonding
	Periodic table		Formulas of compounds
	Reactions and equations		Periodic table
	Properties of gases		Reactions and equations
	Solutions		Properties of gases
	Acids, bases, salts		Solutions
	Safety		Acids, bases, salts
			Equilibrium and kinetics
			Nuclear science
			Organic chemistry
			Biochemistry
			Safety

13-14
Students will use the process skills
to SYNTHESIZE and EVALUATE the following topics

Process Skills	Knowledge Topics
Observing	Measurement
Measuring	Physics
Classifying	Energy
Recording	Force and motion
Predicting	Work
Inferring	Heat
Hypothesizing	Thermodynamics
Investigating	Fluids
Experimenting	Wave properties
Reporting	Sound
Decision making	Light
Valuing	Optics
	Electricity
	Magnetism
	Chemistry
	Properties of matter
	Atomic structure
	Compounds and mixtures
	Bonding
	Formulas of compounds
	Periodic table
	Reactions and equations
	Properties of gases
	Solutions
	Acids, bases, salts
	Equilibrium and kinetics
	Nuclear science
	Organic chemistry
	Biochemistry
	Safety

DISTRICT SCOPE/SEQUENCE FOR PHYSICAL SCIENCE

Knowledge Topics	Grade Level K	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Measurement															
Physics															
Energy															
Force and motion															
Work															
Heat															
Thermodynamics															
Fluids															
Wave properties															
Sound															
Light															
Optics															
Electricity															
Magnetism															
Chemistry															
Properties of matter															
Atomic structure															
Compounds and mixtures															
Bonding															
Formulas of compounds															
Periodic table															
Reactions and equations															
Properties of gases															
Solutions															
Acids, bases, salts															
Equilibrium and kinetics															
Nuclear science															
Organic chemistry															
Biochemistry															
Safety															

Scale to interpret levels of emphasis for each topic:
(See Suggested Scope/Sequence, page 47, and Levels of Emphasis, page 12):

NA	1	2	3	4	5
not appropriate for grade	incidental	awareness	comprehension	application	analysis and evaluation

---

PHYSICAL SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(K-3 Sample)

Knowledge topic: Physical Properties Grade level: K-3

STUDENT OUTCOME EXPECTED

Student will be able to:

classify an object by its physical characteristics (properties).

EMPHASIS LEVEL (circle one)

(Awareness (2)) Comprehension (3) Application (4)

Analysis and Evaluation (5)

RESOURCES

Textbook series

Developmental Activities Project (DAP) Teacher's Guide, Grant Wood Area Education Agency

A-Blocks and Teacher's Guide

Teacher-made set of objects (25 to 50 objects in a set)

ACTIVITIES

1. Student groups objects based on physical properties. (Teacher's directions: Put together the objects that go together. What is the name of this group?)

2. Student regroups the set as many ways as possible. (Teacher's directions: Can you group them another way? Can you make fewer/more groups?)

3. Student repeats activities one and two with different sets of objects, such as buttons, shells, shapes, keys, etc.

EVALUATION

Using a different set of objects, the student (1) classifies them by a consistent criterion, such as color, and (2) subdivides them by a second criterion, such as shape.

(The test set of objects consists of three cubes, three pyramid shapes, and three spheres, with one of each shape painted red, blue, or green.)

PHYSICAL SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(4-6 Sample)

Knowledge topic: Electricity Grade level: 4-6

STUDENT OUTCOME EXPECTED

Student will be able to:

light a bulb using one bulb, one battery, and one piece of wire. The student will also be able to predict which circuits will light up when presented a prediction work sheet.

EMPHASIS LEVEL (circle one)

Awareness (2) (Comprehension (3)) Application (4)

Analysis and Evaluation (5)

RESOURCES

ESS teacher's guide for Batteries and Bulbs
Prediction work sheets
1 D battery for each student
1 #48 bulb for each student
1 eight-inch plastic-cover copper wire for each student

ACTIVITIES

1. The students are given the equipment they need and are asked to find a way to make their bulb light up. They will be given sufficient time for exploration.
2. When they have found a way, they may draw their way on the board. They will be told there are a number of ways to do this and they should look for other solutions.
3. The class will discuss the drawings on the board and draw some conclusions about what is necessary to make electricity flow.

EVALUATION

1. The students will be given a prediction sheet with various circuits pictured. They will predict whether these circuits will enable the bulb to light.
2. The students will be asked to relate what they learned to the electric circuits in their home. This may be done through discussion or through a written assignment.

PHYSICAL SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(7-8 Sample)

Knowledge topic: The Periodic Table Grade level: 7-8

STUDENT OUTCOME EXPECTED

Student will be able to:

predict the oxidation states of most of the elements in groups IA-VIIIA of the Periodic Table.

EMPHASIS LEVEL (circle one)

Awareness (2) (Comprehension (3)) Application (4)

Analysis and Evaluation (5)

RESOURCES

Film on electron cloud and oxidation states (Area Education Agency 6)

ACTIVITIES

Lecture about how atoms give away, accept, and share electrons.

EVALUATION

Use a written text constructed by the teacher to check the student's understanding.

PHYSICAL SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(9-12 Sample)

Knowledge topic: Work Grade level: 9-12

STUDENT OUTCOME EXPECTED

Student will be able to:

calculate the amount of work he or she can do in a specific amount of time.

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) (Application (4)) Analysis and Evaluation (5)

RESOURCES

Physical Resources and Instructions for Motivating Students (PRISM)
(Physics Department, University of Northern Iowa)

ACTIVITIES

1. Each student will calculate work for a given activity and record the time needed to perform the work.
2. Each student will devise a method for expressing the rate at which the work is being done.

EVALUATION

Students will turn in a laboratory report of the work they did and of the rate the work was being done.

PHYSICAL SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(13-14 Sample)

Knowledge topic: Gases Grade level: 13-14

STUDENT OUTCOME EXPECTED

Student will be able to:

predict the pressure change that accompanies a volume change of an ideal gas at constant temperature.

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) Application (4)

(Analysis and Evaluation (5))

RESOURCES

Textbook

Film strips

Computer program (Plato)

ACTIVITIES

1. Laboratory experiments with a manometer.
2. Students will graph data.

EVALUATION

Quizzes

Formal tests

PHYSICAL SCIENCE STUDENT OUTCOMES DEVELOPMENT FORM
(Teacher's Sample)

Knowledge topic: _____ Grade level: _____

STUDENT OUTCOME EXPECTED

Student will be able to:

EMPHASIS LEVEL (circle one)

Awareness (2) Comprehension (3) Application (4)

Analysis and Evaluation (5)

RESOURCES

ACTIVITIES

EVALUATION

Evaluation

EVALUATION

An evaluation component should be integral to all science curriculum development and implementation efforts. This science curriculum model guide will address two evaluation categories, namely program quality and student progress. Although teacher effectiveness is vital, often to the point of being the keystone to effective school science programs, it is beyond the purview of this curriculum model.

PROGRAM QUALITY

One very important way to improve science education is to identify an appropriate instructional model about which to organize the science program. This guide was developed to enable educators to contour their science curriculum to their unique demographic and educational needs. It enables them to conduct a qualitative assessment of their educational needs and to make appropriate modifications with confidence. The Instructional Framework depicted in Table 1 represents a merging of the major curriculum components (knowledge, process skills, application) of the Iowa science curriculum model presented in this guide with appropriate evaluation techniques. The framework was developed by 50 of this nation's premiere science educators at the 1986 Exeter II Conference in Exeter, New Hampshire, and is directly parallel with the Iowa model.

The Iowa science curriculum model represents the capstone of seven years of development and refinement by many of Iowa's most knowledgeable and proficient science educators. It was designed to facilitate the development of the local school curriculum by providing educators with proven guidelines for conducting a curriculum assessment as well as the essential "process skills" and knowledge items (life, earth, physical sciences) for confidently synthesizing the most appropriate student outcomes for their courses.

Conducting the science curriculum assessment process outlined in this guide regularly will enable educators to more confidently address the following program science goals for students:

1. To develop the science process skills of observing, measuring, classifying, exploring, recording, predicting, inferring, hypothesizing, investigating, experimenting, reporting, decision making, and valuing.

2. To have knowledge of major facts and concepts of science.

3. To be able to seek information and to carry out simple investigations to verify or generate information.

4. To demonstrate the ability to approach problems and to solve them in a systematic way.

Table 1

INSTRUCTIONAL FRAMEWORK

	Acquiring Knowledge	Developing Technical Skills	Developing Thinking Skills	Understanding Relations Among Science, Technology, and Society
Educational Aim	Acquire an organized body of scientific knowledge.	Know where, when, and how to collect and organize data and communicate information.	Develop patterns of reasoning and rational thought.	Develop an understanding of the interdependence of science, technology, and society.
Teaching Strategies Activities, and Materials	Lectures, audiovisual demonstrations, worksheets, textbooks, drill, vocabulary lists, discussions, experiments, computers, pretesting, tests, puzzles.	Laboratory investigations, math problems, measurements, charts and graphs, science literature, computer programs, written laboratory reports, research papers, reading and writing instruction.	Coaching, exploring explaining, evaluating, synthesizing classifying, analyzing, hypothesizing, predicting, separating and controlling variables, decision-making projects, brainstorming, examining alternatives, public speaking assignments, "wait" time, debates, independent study, creative problem solving.	Current events, role playing, exchange of personnel, field trips, guest speakers, debates, roundtable discussions, simulations, surveys, films, independent study, reading, interviews.
Student Learning	An understanding of concepts and the ability to perform on informal and formal evaluations.	The ability to use laboratory equipment, read and use scientific literature, and apply math skills.	The ability to make decisions, reason, formulate questions, express ideas, carry out library research, and communicate the knowledge, skills, and values of science and technology.	The ability to relate and apply science and technology to life and to investigate and evaluate alternative values, motives, and attitudes relative to the limits and potentials of science and technology in society.
Evaluation Techniques	Multiple choice tests hands-on activities, written passages to read and summarize.	Hands-on activities, application of skills to a new laboratory situation.	Essay questions that require application of scientific knowledge, analysis of data, problem solving. Puzzles or problems that require using skills students have been learning.	Problem-solving activity involving a local STS issue culminating in oral reports, written reports, panel discussions, visual displays. Teacher evaluation of students' choice of sources of data, differentiation between fact and opinion in sources, thoroughness of data collection, ability to graph or otherwise display data, thoroughness of ethical analysis, conclusions drawn from analysis of data.

Reprinted with permission from the National Science Teachers Association.

5. To be aware of societal issues caused by the application of science and technology.

6. To make value decisions related to themselves, their society, and their environment.

7. To be aware of the importance of science in may different careers.

STUDENT PROGRESS

Evaluating student performance has historically been one common means of securing feedback concerning student progress in a subject area. In science, the inclusion of student hands-on laboratory investigations and experiments introduces another dimension of learning. In addition to acquiring knowledge, the student is expected to become reasonably proficient in process skills, thinking skills, and relating such skills to his or her life in a science- and technology-dependent society.

Teachers should periodically attempt to view the course they are teaching from the student's perspective. This is especially true when attempting to assess student performance. Diversity in teaching methods and conducting student evaluations is the key to maintaining both teacher and student interest in teaching and learning.

Table 1 suggests various methods for educators to incorporate in assessing student progress in each of the learning dimensions described in the previous paragraph. Each of these dimensions will now be discussed in greater detail.

DIMENSION 1 - ACQUIRING KNOWLEDGE

The technique most often incorporated for assessing the knowledge dimension of student learning progress is the written test. Such tests should be viewed as one example of the wide range of such assessment instruments. Written standardized evaluation instruments such as those described in the Compendium of Standardized Tests (National Science Teachers Association, 1985) have a place in the assessment process. However, they should only complement others.

In Iowa, educators may wish to use Project Measure, an objectives-based assessment system. Contact Robert King, Northern Trails Area Education Agency (1-800-392-6640).

Teacher-developed tests concerning the curriculum materials presented are also effective methods for assessing student understanding of facts, principles, concepts, theories, and laws. Such assessments should be conducted periodically as a method for discovering which students need assistance. Such measures should be viewed as a way for teachers to keep their finger on the pulse of individual student learning, not as a method for prodding students into action.

Educators may wish to include hands-on activities, during which they observe student performance, as an additional mechanism for assessing student understanding of science knowledge. Such observations enable the teacher to gain information about the students' cognitive understanding as well as their ability to apply such knowledge to laboratory operations.

Oral quizzes with students allow the teacher to probe student understanding of various concepts, facts, and theories, and are another effective evaluation method. Although this is a time-consuming evaluation process, it can yield extensive information about student understanding of science, when used selectively.

DIMENSION 2 - DEVELOPING PROCESS (TECHNICAL) SKILLS

The most convenient method for teachers to use in assessing this dimension of student learning is to observe student performance during laboratory activities and experiments. Teachers may wish to develop a checklist of the process skills identified in this guide by grade block (K-3, 4-6, 7-8, 9-12, 13-14) and observe student performance of each of these skills during lab exercises. Since the development of process skills encompasses one-third of the time suggested in this model for the learning of science, teachers must be certain that such activities occupy a significant portion of their science instructional time. When involving students in such hands-on activities, teachers should be certain that they address the three duties in order to avoid negligence suits.

Duties of the Teacher in Avoiding Negligence

1. Instruction is appropriate for the students involved.
2. Supervision is adequate for the age level of the student and the environment in which the learning is occurring.
3. Equipment is designed for the age level of the student using it; students are instructed in the proper usage of such equipment, including any dangers; and the equipment is properly maintained.

A teacher who uses good judgment in addressing each of these duties can proceed with confidence with activities involving students.

Teachers may periodically wish to use laboratory practical examinations as an interesting and challenging method for assessing student process skills development. The laboratory practical should be viewed as an assessed review of the laboratory exercises or experiments conducted during the science course. Stations are established in convenient places in the laboratory to which students circulate and answer questions concerning the lab exercise, experiment, or equipment positioned there. Talented students can often be involved in the setup of such practicals; other students enjoy this type of assessment as a diversion from the normal routine.

Computer simulation programs may also be valuable as an alternative method for assessing student achievement in the realm of process skills development. Many of the recent computer simulation programs developed for science require extensive student involvement in data collection through the manipulation of laboratory equipment as well as the interface of such equipment with the computer. Evaluation is often an effective component of such contemporary computer software programs.

DIMENSION 3 - DEVELOPING THINKING SKILLS

The inclusion of open-ended essay questions on written tests is an effective way for teachers to assess how students address problems. The logic students incorporate in dealing with unstructured activities can often be observed by carefully analyzing their descriptive writings. Learning problems and misunderstandings can also be discerned by exposing students to such evaluations.

Written problems, with varying degrees of student assistance provided, are another effective method for assessing student performance. Periodically, in place of the usual teacher-administered written quiz, educators may wish to provide students with a single open-ended question which requires them to synthesize the information provided in the course into a logical response. This type of activity may be done with individuals as well as small groups.

Open-ended laboratory exercises may also be explored with students periodically. Activities may have varying degrees of assistance provided to students depending on their intellectual capabilities and their experience with unstructured problems. In some instances, teachers may provide students with the exercise, title, purpose, materials, and methods and ask them to complete the remaining results and conclusions. This is the typical format for most commercial textbook lab manuals. The problem with such approaches is that students know that they are merely following rote, cookbook procedures to predetermined answers. There is little stimulation for them. By contrast, if the teacher merely provides the title and purpose of the activity and allows the students to use their judgment in resolving the problem, science might become more realistic and challenging to them. Although teachers may not wish to conduct such open-ended activities for all labs, periodic attempts can increase student interest perceptibly.

Teachers may also wish to explore the incorporation of brain teasers or puzzles as a method for assessing student progress in this area. Observing student performance as individuals and their effectiveness in solving problems as part of a group can reveal personal learning problems as well as identify exceptional student creativity.

Requiring students to submit written laboratory reports about exercises or experiments they have conducted can also reveal the reasoning patterns students incorporate in resolving science problems. Periodically, teachers may wish to allow students to conduct an experiment and provide a write up of it as they deem most appropriate. Teachers may wish to review the Science Teaching and Development of Reasoning series available from the University of California, Berkeley, to assist them in recognizing student reasoning development patterns.

DIMENSION 4 - UNDERSTANDING APPLICATIONS (understanding relationships among science technology)

Teachers may wish to have students attempt, through role playing or simulation activities, to resolve a local science/technology issue. Teachers should pay special attention to the types of data students use as the basis for their decisions. Patterns for resolving the problem which the student(s) use to resolve idealism vs. practicality issues, and their empathy for others. Written reports, panel discussion, and small group interactions can all be incorporated as the basis for such activities. Teachers should be especially critical of the students' differentiation between fact and opinion in sources, thoroughness of data collection, ability to graph or otherwise display data, completeness of ethical analysis, and conclusions synthesized from the analysis of the data.

Evaluating student progress is critical to all science programs, teachers, and students: The key is to keep learning interesting and evaluation effective as a learning experience itself. This can best be attained through selective usage and diversity of evaluation types.

IMPLEMENTATION SCHEDULE

Completion date

1. Establish science curriculum committee. Select representatives from each of these areas: administration (e.g. principal, assistant superintendent, curriculum specialist); science teachers K-14 with all buildings and grade levels represented; consultant (e.g. area education agency, college/university, DE); and others (e.g. counselors, school nurse, lay person, minority representation according to the Code of Iowa 257.25 (11), 670-3.5 (257). _____

2. Time should be provided for curriculum work. Schedule adequate time and finances during the school year for curriculum planning, development, implementation, and evaluation. _____

3. Discuss current trends in science education. Arrangements should be made for a knowledgeable consultant to speak with the committee concerning contemporary trends and problems in science education as they relate to the district. _____

4. Review the Code of Iowa for the Minimum Curriculum Requirements and Standards for Approved Schools, K-12 (Appendix A, pages ApA 1 and 2). The science curriculum committee should conduct a careful review of the Iowa Curriculum Standards and of this document as it applies to the local district. _____

5. Develop a philosophy of science teaching. The science curriculum committee should develop a written philosophy of science education specific to local needs. The comprehensive nature of science and its essential purpose in developing scientific literacy in all students should be a major feature of the statement.

6. Establish goals for science programs. Refer to Sample Science Goals for Students (page 3). _____

7. Review the Suggested Scope/Sequence for each area of science instruction (life on page 10, earth on pages 22 and 23 and physical on page 39). _____

8. Modify Suggested Scope/Sequence and determine the Scope and Sequence in each science area for each grade level for the district. Record these on the appropriate District Scope/Sequence form (life on page 22, earth on pages 38 and 39, and physical on page 51). _____

9a. Make copies of the appropriate Student Outcomes Development Form (life on page 20, earth on page 37, and physical on page 49). _____

9b. Refer to the District Scope/Sequence form and select a knowledge topic to be developed. _____

9c. Place the knowledge topic and grade level in the spaces provided at the top of the page. _____

9d. Determine the student outcome(s) for that knowledge topic. Most student outcomes will be developed by combining a process skill with a knowledge topic. It is suggested that the Suggested Student Outcomes Development Tables (Life - pp. 11-14, Earth - pp. 24-29, Physical - pp. 40-42) be used to <u>develop local district student outcomes</u>. However, this is not necessary or possible in all cases. _____

9e. Complete the level of emphasis category. Refer to the District Scope/Sequence form for this number (1-5). _____

9f. Complete the resources category. The teacher should make every effort to use a diversity of instructional resources, such as films, computer programs, manipulatives/lab apparatus, field trips, outside personnel. Refer to Appendix B for such items. _____

9g. Complete the activities category. The teacher should make every effort to use a variety of instructional methods, such as laboratories, worksheets, lectures, and oral and written reports. Most science units should include hands-on experience for the student. The teacher may explore the use of such items as kits (purchased or locally made), activities from periodicals, and activities from teacher resource books. _____

9h. Complete the evaluation category in view of the emphasis level. The teacher should use the most appropriate evaluation technique. The teacher should consider how an outcome can be used or applied to a student's life. Some examples of evaluation techniques are a teacher-made test; a standardized test (Iowa Test of Basic Skills, Iowa Test of Educational Development, Project Measure, American College Test, Scholastic Aptitude Test); laboratory practicals; oral reports; written reports; displays; and teacher-recorded observations of student performance. Refer to Table I. _____

10. Assess the physical facilities and safety parameters and recommend necessary changes. _____

Appendices

APPENDIX A

CODE OF IOWA
REQUIREMENTS AND STANDARDS

The Code of Iowa provides minimum curriculum requirements and standards for approved schools (K-12).

MULTICULTURAL, NONSEXIST EDUCATION REQUIREMENT (IOWA SCHOOL STANDARDS)

Pursuant to the authority of section 257.25(11) of the Code of Iowa the following are additions to 670-3.5(257).

The curriculum structure and content, instructional materials, and teaching strategies shall reflect the contributions and perspectives of men and women and diverse racial or ethnic groups to the instructional program. Where sex or cultural-racial stereotyping exists in instructional materials, it shall be brought to the attention of the student and supplementary materials should be used to offset the stereotyping. Multicultural, nonsexist instructional materials shall be adopted at the first opportunity. The curriculum shall include activities which promote an awareness of sexism and cultural-racial bias in the English language 670-3.5(6).

SECTION 257.25 STATES, WHERE APPLICABLE TO SCIENCE AND HEALTH:

257.25(2) Kindergarten level. If a school offers a kindergarten program, the program shall include experiences designed to develop healthy emotional and social habits and growth in the language arts and communication skills, as well as a capacity for the completion of individual tasks, and protection and development of physical being.

257.25(3) Grades one through six. The following areas shall be taught in grades one through six:

SCIENCE, including conservation of natural resources and environmental awareness.

HEALTH AND PHYSICAL EDUCATION, including the effects of alcohol, tobacco, drugs and poisons on the human body; the characteristics of communicable diseases.

JUNIOR HIGH SCHOOL LEVEL

257.25 (4) Grades seven and eight. The following shall be taught in grades seven and eight as a minimum program:

SCIENCE, including conservation of natural resources and environmental awareness.

HEALTH AND PHYSICAL EDUCATION, including the effects of alcohol, tobacco, drugs, and poisons on the human body, the characteristics of communicable diseases, including venereal diseases and current crucial health issues.

HIGH SCHOOL LEVEL

257.25 (6a through 6j) Grades nine, ten, eleven and twelve. The minimum program for grades nine through twelve shall be:

SCIENCE (four units), including physics and chemistry; the units of physics and chemistry may be taught in alternate years.

HEALTH EDUCATION, including an awareness of physical and mental health needs, the effects of alcohol, tobacco, drugs and poisons on the human body, the characteristics of communicable diseases, including venereal diseases and current crucial health issues.

280.10 EYE-PROTECTIVE DEVICES. Every student and teacher in any public or nonpublic school shall wear industrial quality eye-protective devices at all times while participating, and while in a room or other enclosed area where others are participating, in any phase or activity of a course which may subject the student or teacher to the risk or hazard of eye injury from the material or processes used in any of the following courses:

1. Vocational or industrial arts shops or laboratories involving experience with any of the following:

   a. Hot molten metals.
   b. Milling, sawing, turning, shaping, cutting, grinding or stamping of any solid materials.
   c. Heat treatment, tempering or kiln firing of any metal or other materials.
   d. Gas or electric arc welding.
   e. Repair or servicing of any vehicle while in the shop.
   f. Caustic or explosive materials.

2. Chemical or combined chemical-physical laboratories involving caustic or explosive chemicals or hot liquids or solids when risk is involved. Visitors to such shops and laboratories shall be furnished with and required to wear the necessary safety devices while such programs are in progress.

It shall be the duty of the teacher or other person supervising the students in said courses to see that the above requirements are complied with. Any student failing to comply with such requirements may be temporarily suspended from participation in the course and the registration of a student for the course may be canceled for willful, flagrant or repeated failure to observe the above requirements.

The board of directors of each public school district and the authorities in charge of each nonpublic school shall provide the safety devices required herein. Such devices may be paid for from the general fund, but the board may require students and teachers to pay for the safety devices and shall make them available to students and teachers at no more than the actual cost to the district or school.

"Industrial quality eye-protective devices," as used in this section, means devices meeting American National Standard, Practice for Occupational National Standards Institute, Inc.

APPENDIX B

RESOURCES FOR SCIENCE TEACHERS

LIFE SCIENCE RESOURCES

Cornell, Joseph. Sharing Nature With Children (K-6), Earth Sky, 14618 Tyler Foote Crossing Road, Nevada City, CA 95959.

Gallant, Roy A. Our Universe, National Geographic Society, Washington, D.C. 20013.

Iowa Conservationist (K-12), Iowa Conservation Commission, Wallace State Office Building, Des Moines, IA 50319.

Morhold, E. et al. A Source Book for the Biological Sciences, Harcourt, Brace, & World, New York, NY, 10011.

OBIS (Outdoor Biology Instructional Strategies), Lawrence Hall of Science, University of California, Berkeley, CA 94720.

Project Learning Tree (K-12), American Forest Institute, Inc., 1619 Massachusetts Ave., N.W., Washington, D.C. 20036.

Project Wild (K-12), Western Regional Environmental Education Council, Salina Star Route, Boulder, CO 80302.

The American Biology Teacher, National Association of Biology Teachers, 11250 Roger Bacon Dr., Reston, VA 22090.

EARTH SCIENCE RESOURCES

Iowa Geology Newsletter, Iowa Geological Survey, 123 N. Capitol Street, Iowa City, IA 52242.

The Earth Scientist, Journal of the National Earth Science Teachers Association, Dept. of Geological Sciences, Michigan State University, East Lansing, MI 48824.

Journal of Geological Education, National Association of Geology Teachers, c/o Allen Press, Inc., P.O. Box 368, Lawrence, KS 66044.

PHYSICAL SCIENCE RESOURCES

Energy Conservation Activity Packet (K-6), Instruction and Curriculum Division, Iowa Department of Education, Grimes State Office Building, Des Moines, IA 50319.

Brinkerhoff, R.E., and R.E. Yager. Exerter II Conference: Science and Technology Education for Tomorrow's World, National Scien : Teachers Association, Washington, D.C. 20009.

Channel 13 News, Dept. of Chemistry, University of Waterloo, Ontario, Canada N26361.

Joseph, A. et al. A Source Book for the Physical Sciences, Harcourt, Brace, & World, New York, NY 10010.

Journal of Chemical Education, American Chemical Society, 20th & Northampton Streets, Easton, PA 18042.

Science Activities in Energy (4-6), U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

COMPREHENSIVE RESOURCES

Compendium of Standardized Tests, National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington, D.C. 20009, 1985.

DeVito, Alfred, and Gerald Krockover. Creative Sciencing/Ideas and Activities (K-6), Little, Brown, and Co., Boston, MA 02100.

DeVito, Alfred, and Gerald Krockover. Creative Sciencing/A Practical Approach (K-6), Golden Nature Guides, Golden Press, New York, NY 10011.

Iowa Science Teachers Journal, Iowa Academy of Science, University of Northern Iowa, Cedar Falls, IA 50614.

Outlook, Environmental Education Enrichment (K-12), Iowa Department of Education, Grimes State Office Building, Des Moines, IA 50319.

Ranger Rick's Nature Scope (K-6), National Wildlife Federation, 1412 16th St., N.W., Washington, D.C. 20036-2266.

Russell, Helen Ross. Ten-Minute Field Trips (K-6), J.G. Ferguson Publishing Co., Chicago, IL 60607.

School Science Laboratories: A Guide to Some Hazardous Substances: U.S. Consumer Products Safety Commission, Washington, D.C. 20007. (Available from State Science Consultant, Iowa Department of Education.)

Science and Children. The National Science Teachers Association, 1742 Connecticut Ave. N.W., Washington, D.C. 20009.

700 Science Experiments for Everyone (K-6) compiled by UNESCO, Doubleday and Company, Garden City, NY 11530.

Journal of College Science Teaching. The National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington, D.C. 20009.

Karplus, R. et al. Science Teaching and the Development of Reasoning. University of California, Berkeley, CA 94720.

Science Scope: A Quarterly for Middle/Junior High Science Teachers. The National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington, D.C. 20009.

The Science Teacher. The National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington, D.C. 20009.

Science 86. American Association for the Advancement of Science, Subscription Dept., P.O. Box 10790, Des Moines, IA 50340.

Others in this series of curriculum guides:
Arts, Foreign Language, Language Arts, Mathematics, and Social Studies